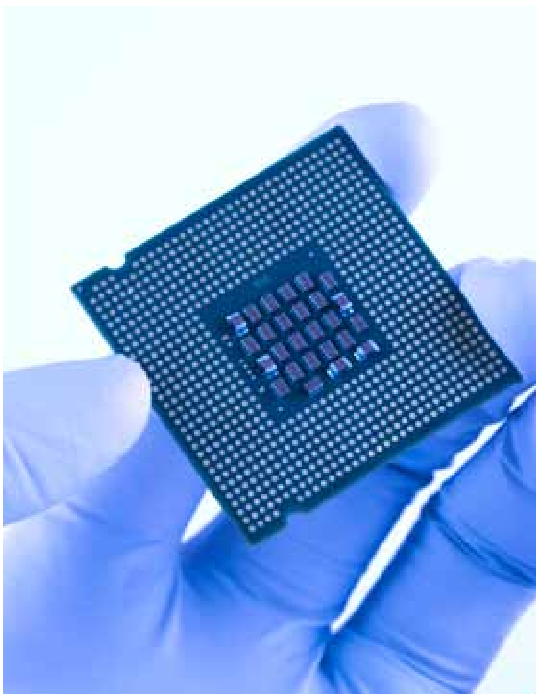
National Aeronautics and Space Administration

technology opportunity

A Method for Modifying Silicates for Better Dispersion in Nanocomposites

Improves processability and final material properties



Innovators at NASA's Glenn Research Center have developed a method to prepare and disperse silicates in a polymer matrix, creating a nanostructured material with enhanced chemical and physical properties. The method involves the co-exchange of an alkyl ammonium ion and a monoprotonated diamine with interlayer cations of the silicate. Layered silicates are useful fillers in polymer matrix composites, as their platelet morphology and high aspect ratio contributes to greatly improved thermal, mechanical, and barrier properties.

Benefits

- **Strong:** Increases polymer lifetime, with enhanced strength and elastic modulus
- **Affordable:** Requires fewer resources than conventional methods
- **Adaptable:** Does not require modifications to existing polymer processing procedures

Applications

- **Aerospace components**
- **Cryogen storage tanks**
- **Food and beverage storage containers**
- **Fuel cell storage tanks for automobiles and aircraft**

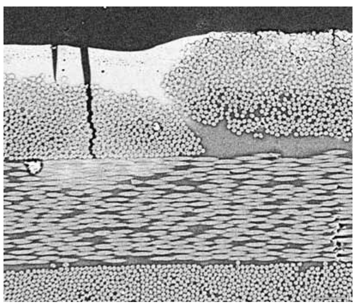


Figure 1. Neat resin matrix composite (aged 500 hours at 288° C).

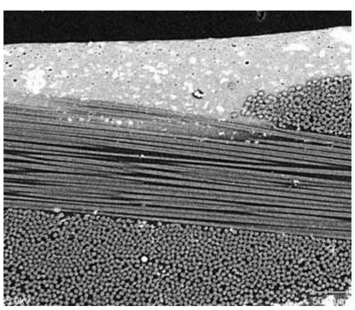


Figure 2. Nanocomposite matrix composite (aged 500 hours at 288° C).

Electron backscatter images show cracking of a neat resin matrix composite (Figure 1) in comparison with a nanocomposite matrix composite (Figure 2). The images show that the dispersion of the silicate into the matrix resin reduces polymer oxidation during aging and reduces the amount of cracking in the matrix significantly.

Technology Details

Polymer-silicate nanocomposites are an attractive means of improving matrix resins in carbon-fiber-reinforced composites. Organic modification of the silicate aids dispersion into the polymer matrix and provides a strong interaction between the clay and the matrix. The dispersion of the layered silicate clay improves the stability as well as the stiffness, strength, and barrier properties of polymers without altering current processing techniques.

How It Works

Ion exchange of the interlayer cations of a layered silicate with a protonated aromatic diamine essentially tethers one end of the diamine to the silicate, leaving the second amine free for reaction with monomers during polymer synthesis. Incorporation of an alkyl ammonium ion into the silicate galleries helps to keep the oligomer melt viscosity low during processing. The presence of the diamine allows chemical reaction between the silicate surface modification and the monomers. This reaction strengthens the polymer silicate interface, ensuring irreversible separation of the individual silicate layers.

Why It Is Better

PMR-15 silicate nanocomposites were investigated as a matrix material for carbon-fabric-reinforced composites. PMR-15 was chosen as it is a widely used, commercially available, highly cross-linked, thermally stable thermosetting polymer with excellent processability, mechanical properties, and thermal oxidative stability; however, this method of modifying clay can be applied to any polymer matrix. Application of the Glenn process improves the composite material's physical properties. Dispersion of the organically modified layered silicate into the PMR-15 matrix enhances thermal oxidative stability by up to 25 percent, after aging at 288°C for 1,000 hours. Mechanical properties such as the flexural strength, flexural modulus, and interlaminar shear strength are increased by up to 30 percent. The enhanced barrier properties of the polymer-clay hybrid slow the diffusion of oxygen into the bulk polymer, thereby slowing oxidative degradation.

Patents

Glenn has patented this technology (U.S. Patent No. 6,828,367).

Licensing and Partnering Opportunities

Glenn's Technology Transfer and Partnership office seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to discuss partnership opportunities involving this method for modifying silicates for better dispersion in nanocomposites technology (LEW-17339-1) for commercial applications.

For More Information

For more information about this and other technology licensing opportunities, please visit:

Technology Transfer and Partnership Office
NASA's Glenn Research Center
E-mail: ttp@grc.nasa.gov
Phone: 216-433-3484
http://technology.grc.nasa.gov